

MAECTITE® CHEMICAL TREATMENT TECHNOLOGY:  
SELECTED CASE HISTORIES FOR LEAD AND CADMIUM

Karl W. Yost  
Alan Elia, Jr.  
Steven A. Chisick, C.P.G.

For Presentation at:

SUPERFUND XV  
November 29 - December 1, 1994  
Conference and Exhibition Proceedings  
Washington, DC

*Sevenson Environmental Services, Inc.  
8270 Whitcomb Street, Merrillville, IN 46410  
(219) 756-4686*

# **MAECTITE® CHEMICAL TREATMENT TECHNOLOGY: SELECTED CASE HISTORIES FOR LEAD AND CADMIUM**

**Karl W. Yost**  
**Director of Treatment Services**

**Alan Elia, Jr.**  
**Project Manager**

**Steven A. Chisick, C.P.G.**  
**Senior Geologist**

**Sevenson Environmental Services, Inc.**  
**Niagara Falls, New York**

## **ABSTRACT**

Chemical treatment for lead and other heavy metals, including cadmium, in soil and solid waste with the MAECTITE® process creates hard, insoluble mixed mineral forms. Heavy metals are rendered non-hazardous under RCRA definition, therefore, treated material may be disposed as a special waste. The MAECTITE® chemical treatment process forms non-leachable minerals through isomorphic reaction-series induced nucleation.

Unlike cementitious, silicic, and/or pozzolanic methods where contaminants are restrained in a mixture with binding agents or hydroxides subject to degradation from physical and chemical conditions, MAECTITE® utilizes true bonding and crystal nucleation from disassociated metal species and yields metal-substituted crystal compounds. The metal-substituted crystal precipitates are in the hexagonal and orthorhombic crystallographic systems that are stable in acidic, alkaline, and other environmental settings. Succinctly, mixtures are readily degraded/separated by physical and chemical forces; compounds are not.

Waste subjected to optimized MAECTITE® chemical treatment complies with RCRA limits as determined by USEPA's EPTOX and TCLP test methods, and the Multiple Extraction Procedure (MEP) that simulates 1000 year exposure to acidic environments. The MAECTITE® chemical treatment process often reduces waste volume by over 20% with limited or no mass increase partially due to increased particle density, eliminated interstitial space, dehydration of the waste matrix, and destruction of semi-stable carbonates. Although water is required as a reagent mixing lubricant, treated material complies with the paint filter test and chemically cures within 3-5 hours. Increased curing times allow liberated and reagent mixing waters to evaporate.

Complete success of the MAECTITE® process at full-scale production levels for all projects attempted to date is

partially attributed to treatability studies that apply the technology to specific wastes at the viability, bench, and engineering-scale levels. Under extensive and rigid QA/QC, treatability results have been upscaled to full production on over 200,000 tons of hazardous material. Wastes treated have included: all types of soil; peat and humic material; debris and construction rubble (BDAT); paint and abrasives; foundry sands and smelter slag; auto fluff; ore processing residuals; lead shot and shooting range sand with spent projectiles; carbon dross; landfill contents; glass; battery casings and lead battery parts; wastewater; filter cake and sludges; aquatic sediments; wire chop; and organic API separator sludges with tetraethyl lead (TEL). No leachable lead bearing waste/material has been identified to be resistant to the MAECTITE® chemical treatment process.

Full-scale production rates onsite have ranged from a few (48) 55-gallon drums in one day to over 2000 tons in a 12-hour production shift. MAECTITE® processing is accomplished insitu or exsitu, and in batch or continuous modes of operation. Heavy metal levels in untreated material have ranged up to 29.9% total lead and TCLP lead to over 4,000 mg/l.

The patented MAECTITE® chemical treatment technology has been accepted into the USEPA SITE program, included in the US/German Bilateral Agreement, and was nominated for the 1991 President's Environment and Conservation Challenge Award. Technology improvements are currently patent-pending.

## **EXECUTIVE SUMMARY AND BACKGROUND**

This paper presents typical approaches to the evaluation of the MAECTITE® technology for use on lead and heavy metal bearing waste streams and materials ranging from treatability scale viability demonstrations to full-scale project applications. In addition, a brief technology history

and technical overview is presented with analytical data supporting a range of applications to various lead bearing materials. Finally, two (2) full-scale projects are examined that depict a range of project magnitudes and complexities that incorporated common MAECTITE® technology application forms.

## OVERVIEW OF MAECTITE® TECHNOLOGY

In the early to mid-1980's, traditional treatment of heavy metals in soil and solid waste utilized physical binding and hydration mechanisms to create structures that immobilized heavy metals by lattice containment, encapsulation, entrapment, absorption/adsorption, and/or aggregate interlock. Unfortunately, effective treatment results as indicated by the USEPA's EPTOX method were achieved at the expense of waste matrix mass and volume increase due to bulking (therefore, possible analyte dilution) from stabilization and solidification agents and hydrated water.

Although EPA leach tests (currently including TCLP and expanding to include MEP methods) were used to examine leachability of metal analytes in acidic conditions, material treated by cementitious, silicic, and pozzolanic methods required extended periods of curing prior to treatment compliance determinations by costly and lengthy geotechnical test methods. The geotechnical methods such as unconfined compressive strength and permeability were (and are) required to demonstrate that the physical binding mechanisms of the end-product mixtures central to the stabilization process could withstand rigorous physical conditions that may be encountered in final waste placement areas.

The elevated cost to site remediation projects stemming from treated-waste mass and volume increase (transportation and/or final disposition), prolonged project durations owing to treated waste curing times and analytical needs created a situation where an alternate treatment approach had to be found. Furthermore, treatment product longevity and stability concerns associated with physical mixtures raised liability issues for waste generators, PRP's, and waste disposal facilities. These issues led to a rethinking and reevaluation of traditional stabilization/solidification methods.

In industrial, accidental and landfill situations, the organic and inorganic components of a soil are not necessarily formed under chemical equilibrium. Likewise, the behavior of metal ions is even more highly involved with a large number of possible process interactions with ill-defined dissolved and particulate components.

The control of problem metal ions has been a long sought quest by a large number of researchers, especially physical chemists. An enormous effort has been spent by these researchers in determining and tabulating mineral solubility data and curves for pure-phase solids. Studied as absolutes, pure-phase solids are not natural; and certainly, pure-phase solids are not what one encounters in industrial, accidental and landfill situations. Researchers rigorously trained in

basic mineralogy, geochemistry and material science have taken a different approach, non-pure and coprecipitated intertwined mineral-solids.

The MAECTITE® chemical treatment process is a classical mineralogy and geochemistry approach to control of problem inorganic ions through mineral dissolution-precipitation reactions by the formation of a suite of isomorphic mineral-solids through the manipulation of non-problem inorganic ions. As defined by the mineralogist, isomorphism occurs when an ion at high dilution is incorporated by mixed (unlike) crystal formation into a precipitate, even though such formation would not be predicted on the basis of crystallographic, and ionic radii. This is very different from that of the physical chemist, where isomorphism is a chemical state in which various elements or molecules enter into a greater or lesser degree the crystal-lattice of a mineral-solid without causing any marked change in the crystal morphology and stay within the same crystallographic system.

In the broader sense, the MAECTITE® chemical treatment process advantageously accesses the isomorphic relations that exist between a series of mineral-solids of analogous chemical formulas and crystallographic structures. This concept accounts for elements or molecules of distinctly different chemical character, and even of different valence, substituting for each other without changing the general geometry of the crystalline forms. The analogous formulas possess an equal number of atoms and of positive and negative components while analogous crystallographic structures are composed of geometrically similar basic crystal-units in which an equal number of atoms are arranged in a geometrically similar manner. Sometimes the crystallographic system does change, but only into a system with compatible basic crystal-units (e.g. a rhomb). To the mineralogist, this phenomenon is termed twinning.

When the relative size of the atoms and certain of their physical properties (e.g. specific gravity, optical properties, etc.) are nearly the same, one has a potential Isomorphic situation. This situation can be explained by Pauling's electronegativity potential. If two elements or molecules have a similar radii and the same charge, the one with the lower electronegativity potential will be preferentially concentrated in early formed specimens of the crystallizing mineral-suite.

Many have noted the undersaturated conditions of most waters encountered in nature. The control mechanism is not known, but is believed to be coprecipitation and the high electrostatic condition produced during precipitation events. The surface charges of particulates in natural waters, which may arise from chemical reactions at the surface, by lattice imperfections at the solid surface, by isomorphic replacements within the lattice structure and by adsorption of surfactant ions which is strongly Eh-pH dependent. Eh-pH relationships are the most definitive element in near or at surface soil conditions. Eh-pH diagrams are constructed

as "absolute-pure" mineral solids which is not the actual situation found in natural, industrial, accidental, and landfill settings. Eh reflects the abundance of available electrons in the environment; thus, a large number of electrons equates with a reducing environment while an absence of electrons equates with an oxidizing environment. Correspondingly, pH represents an abundance of accessible protons with a large number of protons representing an acid environment and a scarcity of protons representing a basic environment. Since electron and proton particles have opposite charges, one would expect that an abundance of one particle would translate into a shortage of the opposite particle. Thus a high Eh, an oxidizing situation, would have a concurrently low pH, an acidic situation.

Plainly, Eh-pH are effects of  $H^+$  ion activity which is the major control of solubility in the MAECTITE® chemical treatment process. The convenience of Eh-pH diagrams is the coincident plotting of the interactions of dissolved materials only, dissolved materials and other natural solids, and reactions between two or more solids. Crystallographic geometry, the type of bonding on and near the surface of crystals, the size of the individual mineral crystals, the chemical character of the participating solution, and pressure and temperature relationships are a few of the principal parameters controlling behavior of problem inorganic ions.

Thus, fixation of problem ions and simultaneous admittance into the solid phase is by: 1) unsatisfied valence produced by broken bonds at surfaces and edges of mineral-solids; 2) unbalanced charges caused by isomorphic substitution; 3) dissociation of  $OH^-$  radicals, when the  $H^+$  may be readily exchanged; 4) accessibility of atoms in crystallographic positions when brought to the exchange site as a result of a change in environment; 5) availability of exchangeable constituents in the mobile phase; 6) Eh-pH relationship; 7) general chemistry of the environmental setting; and 8) pressure and temperature conditions.

True mineral dissolution-precipitation reactions have long been the ideal for control of problem inorganic ions. Precipitates tend to carry out of solution other constituents that are normally soluble, causing a coprecipitate. Barriers to precipitation commonly arise because of changes in pH, in oxidation potentials, or ionic concentrations of precipitating salts. Direct precipitation of metal compounds may take place when minor external changes occur, such as mixing with other waters, temperature change, addition or subtraction of gases (i.e. oxygen, carbon dioxide, methane, hydrogen sulfide) or interactions with solids.

Mineral-solids are said to be isomorphic if they have the same type of formula and crystallize in similar geometric forms. If the precipitating mineral-solids are within the same crystallographic system, or compatible systems, no interference to the precipitation event occurs, a phenomenon dreaded by industrial/analytical physical chemists and engineers, but long sought by remediation scientists.

Those cognizant of the problems with waste

geochemistry felt that if metals in soil or solid waste could be converted to stable forms without waste bulking, water hydration, and physical binding mechanisms, remedial project costs and long-term stability issues could be resolved. Fundamental to the concept was the scientific differences between mixtures and compounds where mixtures are degradable by physical forces and compounds are not. Unfortunately, soils and solid wastes are mixtures and create parallel problems never encountered in chemical laboratory conditions as defined in the purest empirical or clinical sense.

Since the MAECTITE® chemical treatment technology incorporates the heavy metal species/ions into complexed molecular structures as compounds, they cannot be degraded or separated from the matrix in leachable form by simple physical forces, except under extreme pressure and heat. This is clearly supported by heavy metal concentration data obtained from extraction fluid after treated material exposure to intense ultrasonic energy for extended periods of time. Non-MAECTITE® treated material using physical binding mechanisms cannot withstand such ultrasonic energy as the endstructures are weakened and/or disintegrated allowing exposed analytes to disperse (Frick's First Law) into extraction fluids.

Long-term stability examined from the chemical perspective by evaluating treated waste integrity after prolonged exposure to acidic conditions becomes the critical component to treated waste longevity, not geotechnical testing. The MEP test was designed by EPA to simulate 1000 year exposure to acid rain and leachate. More importantly, the serial acid extractions chemically overcome the buffering capacity of treated material. Often, primarily with cements and hydroxide treatment methods, unnecessary and excessive treatment additives are applied to the waste so that the leaching test methods (e.g., EPTOX and TCLP) cannot overcome the buffering capacity of the treated waste during the limited extraction duration. Buffering capacity is of critical importance in all hydroxide and hydration treatment approaches.

Examination of published solubility products for metallic hydroxides will reveal that most all metals are insoluble at various alkaline pH ranges. Once the buffering capacity of a waste containing metals is exceeded with acidity, the hydroxides will disassociate, physical binding mechanisms weaken, and metals will leach. MAECTITE® formed mineral crystal compounds are not conducive to degradation in acidic, neutral, or alkaline conditions, hence they remain geologically stable.

Practical application of the MAECTITE® chemical treatment process is culminated by successful full-scale application on hazardous material and waste. Since the technology's inception, over 200 treatability studies have been completed on various material matrices at bench, engineering, and pilot-scale projects with 15 projects addressed at full-scale. A summary of pre- and post-treatment analytical data lead for bearing material is

presented in Table I.

#### CASE HISTORY I: MARATHON BATTERY SUPERFUND SITE, COLD SPRING, NY

The Marathon Battery Superfund Site in Cold Spring, New York is located on the east bank of the Hudson River approximately 50 miles north of New York City. The site's environmental significance is enhanced by its proximity to historic locations such as West Point and the Catskill Mountains. Part of the site contains "Constitution Marsh", a sensitive aquatic ecosystem that is characterized by tidal influence and backwater areas of the Hudson River fiord. Heavy metal presence, primarily cadmium and to a lesser degree, lead, were the result of operations from a now closed battery manufacturing plant.

The Marathon Battery Site consists of three (3) areas that required remediation. They include: the former battery plant facility grounds and vault; a continuous pond and cove area; and East Foundry Cove (EFC) Marsh.

Prior to site remedial activity, extensive site preparations were required. A wide range of work zone conditions were encountered from submerged sediments in quiescent backwaters and flowing river, soupy marsh material, dense clays, coarse gravels and fine sands, and rock cobble. Significant flexibility was required for material handling, preparation, and treatment processing. The magnitude of the site surface area, and the quantity of material to be treated and disposed further added to the complexity of the site. Of critical concern was the high tidal influence zone of the Hudson River as it fluctuated in the cove and marsh areas. This had to be controlled to prevent contaminant migration during excavation and erosion during restoration.

The command and control area for the site consisted of numerous support trailers for office space, decontamination facilities, meeting facilities, tool and spare part storage, a comprehensive onsite laboratory, and a sampling and archive facility. Other substantial support services including electrical power, telephone services, parking for over 100 site workers and visitors were required.

As part of the site setup, clearing and grubbing, and construction of a bermed, contoured and sumped seven (7) acre asphalted pad was required. This was used to stage the two 1000-ton per day MAECTITE® treatment systems, a 2000 gallon per minute water treatment system, and excavated waste soils and treated material during curing and testing phases. Severson also installed a two (2) mile railroad spur with railcar scales for treated material transport.

To delineate the horizontal and vertical extent of cadmium and lead contamination, all areas targeted for remediation in addition to those requiring installation of constructed site support services, had to be surveyed. The site was fenced for security purposes.

Prior to any site remediation, the MAECTITE® chemical treatment process had to be demonstrated to the satisfaction of the site PRP Committee, the USEPA, the U.S. Army

Corps of Engineers, the state of New York, and the community of Cold Spring, New York for each area targeted for remediation. Since complete characterization of the site was not known (i.e., the highest levels of lead and cadmium that were to be encountered) treatment demonstration efforts were exasperating. For QA/QC purposes, Severson utilized a cadmium and lead spiking and treatment procedure that satisfied all concerned parties at the treatability level and before conducting 250-ton lot full-scale demonstration treatments on actual site materials.

In the laboratory at the engineering level, Severson was able to support treatment objectives for TCLP test methods stipulated by the lead regulatory agency. In addition, the selected disposal facility's operating permit required compliance with the EPTOX method, and the PRP Committee required that long-term stability of treated material be examined using the Multiple Extraction Procedure. Treatability data from the pre-remedial studies are presented in Tables II and III.

Severson implemented several value engineering cost saving elements. Most significant was the partial replacement of an earthen dike with a bladder water-structure that controlled water flow produced by tidal influences on the Hudson River. Severson substantially reduced the "footprint" of the dike, lowered the earthen material elevations, and brought the control measure in compliance with high-water levels and the 100 year floodplain limit. The water-structure was approximately 12 feet thick, 6 feet tall, and wrapped around the marsh:pond/cove interface (approximately 1700 linear feet), effectively isolating EFC Marsh. The water-structure's overall elevation could be adjusted by pumping in or releasing water until the correct surveyed elevation was achieved. The use of the water-structure eliminated the import of thousand's of yards of fill material to construct the dike, and its removal during final site restoration. Under the original design, a waiting period of 12 months was required for the earthen dike to settle in the marsh area prior to remedial implementation.

Another value engineering cost saving was the removal of rock and stone from excavated soil prior to treatment by the screening to diameters greater than 1.25 inch. The oversize material was washed and rinsed to remove all surficial total cadmium and lead (< 20 mg/kg) verified by total metal testing followed by TCLP testing to insure it was not hazardous. Decontaminated material was then utilized for backfill during site restoration. This reduced the amount of material to be treated and transported off-site for disposal.

The most substantial value change to the project was the use of the MAECTITE® chemical treatment process. Original remedial treatment designs for the site specified the use of Portland Type I cement at ratio's ranging up to 50 percent by weight with the waste to be treated. By demonstrating the effectiveness of the MAECTITE® process to all regulators and the PRP's, reagent costs were

substantially reduced as was the final mass and volume of material transported offsite for disposal. Treatment dosages of MAECTITE® reagent averaged 3 to 5 percent, with the highest dose of 12 percent applied to select worst-case site material.

The application of MAECTITE® reagent was controlled onsite by a dedicated full-scale laboratory. Material prior to treatment was subjected to various treatment designs at the bench-scale level to verify required dosages. Optimized reagent addition was then utilized by treatment system operators to maximize process efficiency.

Health and safety concerns were of great importance, especially since residential homes were located along one perimeter of the site. A sound and dust isolation barrier was erected along this segment of the property. Comprehensive water spraying activities were used to prevent dry soil and control dust conditions.

For purpose of clarity in this paper, each of the site remedial areas will be discussed separately.

#### East Foundry Cove Marsh

The marsh presented a difficult remedial problem. Material from the area consisted of thick cattail and aquatic vegetation above contaminated marsh sediments entwined with significant tendril root mass. The sediments, peaty with high characteristic plasticity, were water saturated and could not bear any load associated with even foot traffic. Severson designed, built and operated an amphibious hydraulic backhoe excavator and amphibious dump vehicles. These tracked vehicles displaced only 4-6 inches when empty and operating in the marsh.

Prior to excavation, the area was surveyed, gridded at 50 feet nodes, and sampled for total cadmium and lead. Quadrants where contamination was identified to be above site action levels were labeled for removal and subsequent treatment.

The wetland classification of EFC Marsh required Severson to accommodate final restoration plans from project inception. After remediation and contour restoration, the area had to be replanted with offspring from the original vegetative plant species. Severson, in conjunction with the local Audubon Chapter, collected seeds and plants from the predominant species from throughout the marsh. Vegetative patterns associated with marsh contours and water levels had to be mapped for seed collection and project end restoration. Seeds and plants from the ecosystem were taken from the site, germinated and cultured in a controlled environment for later site replanting.

After seed and plant collection in the fall of 1993 by National Audubon Society volunteers, vegetation above the marsh grade was cut and removed prior to subgrade material removal. Each of the grids were excavated to the proper depth with the amphibious excavator and the material transferred directly to the flotation dump trucks. When full, the tracked flotation dump vehicles delivered material to the

asphalted staging pad.

The excavated and staged marsh material was too wet, plastic, and clumped with root mass to allow for direct feed to the MAECTITE® treatment system. Severson utilized industrial disks and tracked vehicles to work the material in lifts and break up the root tendrils while staged on the pad. After material was prepared, it was transferred to piles adjacent to the MAECTITE® treatment system, ready for feed and treatment.

During marsh excavation, Severson maintained dewatering activities from surface water runoff, and groundwater intrusion to excavation areas. These fluids were pumped to the onsite treatment system, treated, and discharged under the former facility's NPDES discharge permit.

Upon completion of marsh excavation where the area was remediated to a total cadmium level of < 100mg/kg, the site was graded and contoured to near pre-project conditions allowing for marsh water channels, "humps", and other distinct natural geomorphic features. A bentonite mat was then placed over all disturbed areas, and final fill material was placed in accordance with pre-construction soil/sediment profiles.

As the project nears completion, (~ 2.5 years ahead of schedule), and after the water-structure and dike removal, approximately 80,000 aquatic plants will be set at 2 feet centers in a vegetative pattern that replicates the marsh's original conditions. Currently, while remediation is still proceeding in the outer cove and pond areas, Severson is maintaining the water and siltation control measures. Erosion control of the exposed marsh surfaces has been accomplished by the seeding of the contoured areas with a rye grass.

With the marsh area remediation completed except for peripheral areas near material handling corridors, Severson has excavated, dewatered, prepared, and treated with the MAECTITE® process approximately 20,000 cubic yards of material. Cadmium was the predominant contaminant present in the material ranging up to 0.1% as a total metal, and 125.2 mg/l in TCLP extract in untreated material (See Table IV). All material was successfully treated to below 1.0 mg/l cadmium as measured by EPTOX and TCLP methods. All treated material was removed from the site by rail car and transported out-of-state for disposal by internment as a non-hazardous waste.

#### Plant Facility

Soil beneath and surrounding the former battery manufacturing facility contained elevated levels of leachable and total cadmium. In addition, previous site remediation activities resulted in the placement of highly contaminated cadmium sediments in a vault area constructed onsite.

Severson utilized grid sampling methods to identify contaminated areas, and applied standard excavation methods to remove all impacted material above the site cleanup action level. Excavated material was screened to

less than 1.25 inch nominal diameter. Soil fines were transported by dump truck to the treatment area for MAECTITE® processing.

Oversize material was decontaminated by washing and rinsing to remove cadmium and lead contaminated soil fines. Successful decontamination of the oversize material was verified by sampling and total metal analysis. The material was then staged for use in the final restoration phase of the project as backfill. All wash and rinse waters were pumped to Severson's water treatment system for subsequent discharge.

Cadmium levels in the plant ground and vault soils ranged from 0.25% to 14.68% total cadmium with TCLP cadmium ranging from about 50 mg/l to 180.2 mg/l. 25,000 cubic yards of material were successfully treated to below 1.0 mg/l TCLP and EPTOX cadmium.

#### Cove and Pond

Contaminated pond and cove sediments were located beneath the Hudson River's backwater extending to depths ranging from 3 to 7 feet below the water surface. These subsurface sediments were removed (currently in progress) using hydraulic dredging methods. The dredge was fitted with an adjustable cutter head that pumped solid material and liquids at a flow of up to 1800 gpm with a solid content of ranging from 3 to 8% by weight. Each pass of the dredge over a specific surveyed sampling grid removed approximately 6-12 inches of deposited sediment material. Root mass and woody materials were shredded by the dredge cutter head and pumping system. Oversize rocks (> 6 inch nominal diameter) were removed by a rock box. Sediments and water were pumped by the dredge through 8 inch fusion-welded plastic piping over distances exceeding 5000 linear feet, depending upon location of removal operations.

All dredge fluids were originally planned to be dewatered by centrifuge technology. Resultant centrifuge cake was to be treated by the MAECTITE® process with aqueous residuals treated by Severson's water treatment. Substantial variation in sediment particle constituents (silt, sand, bits of vegetation, detrital material etc.) prevented efficient dewatering by the centrifuge approach.

Severson then constructed two dewatering basins (650,000 and 550,000 gallon capacities) piped in series for removal of dredge-spoil solids. The supernatant from the basins was treated in the water treatment system with clarified and settled solids dewatered in three (3) plate and frame filter presses. Cake from the presses was conveyed to the MAECTITE® treatment system for heavy metal treatment. Periodically, the settling basins were excavated of accumulated solids, which were, in turn, treated by the MAECTITE® process along with the filter cake.

Although the process change from centrifuge technology to plate and frame methods created some limited disruption, the end result was far superior than had been originally planned as significant volume reduction was achieved

stemming from high solid content of the filter cake. This further minimized the amount of material requiring treatment and offsite disposal.

One isolated area distal from the contiguous site, where cadmium had been detected, was also remediated. A submerged discharge outfall from the former plant to the Hudson River in the vicinity of Cold Spring's municipal pier was identified. Sediments in the former outfall's plume area were removed by hydraulic dredge and clamshell methods within silt curtain control structures. Material was either pumped to the settling basins or delivered by barge to an offloading point and then trucked to the MAECTITE® treatment system pad. An estimated 10,000 cubic yards of material were removed from the pier area and treated by the MAECTITE® treatment process.

Dredging activities are still in progress in the cove and pond areas. It is anticipated that approximately 70,000 cubic yards of material will have been removed from beneath the standing/flowing water level, dewatered and treated with the MAECTITE® process. To date, total cadmium has ranged up to 1.35% and TCLP cadmium to 198 mg/l. All prepared material has been successfully treated to below the 1.0 mg/l limit for both TCLP and EPTOX cadmium.

Once the dredging has been completed, silt control fencing, and the dike and water-structure will be removed between the pond/cove and the marsh. The marsh replanting will then be initiated.

#### MAECTITE® Processing Equipment

To meet treatment production levels with confidence, two (2) process systems with a capacity of approximately 1000 tons per day were mobilized to the site, setup, and operated. By using two systems, planned equipment services, treatment reagent deliveries, and soil/material excavation schedules could further accelerate the project. It was felt that if only one larger system was used, mechanical problems and other downtime could compromise the overall site schedule.

Each MAECTITE® processing systems utilized a tracked excavator to introduce material to the feed hoppers from staged piles of prepared waste. Conveyors in the hoppers carried material through a dual shredder for sizing. The shredded material was then conveyed across a weigh-belt feeder where instantaneous and totalized mass were measured.

The weigh-belts were integrated to ratio controllers that activated MAECTITE® reagent storage silos and automated feeder belts. The logic center in the control panel was programmed on a regular basis, or as needed, depending upon specific waste treatability results generated by the dedicated onsite laboratory. As the rate of waste feed varied, so did the rate of MAECTITE® reagent.

As the MAECTITE® reagent and the waste material were delivered in parallel to the pugmill mixer, water was added to insure proper mixing. Each mixer then directly

discharged blended soil and reagent into a "Moxie" dump vehicle. When full, the dump vehicle transferred material to bins for curing, and subsequent confirmatory sampling and testing.

Storage bins were constructed with cement "jersey barriers" placed on the bermed, contoured, and sumped treatment pad. The 250-ton capacity bins were labeled for treatment "lot" tracking. When curing was completed after approximately 3-5 hours (longer in winter months), representative samples were collected and sent to an offsite laboratory for confirmation of treatment analyses. Any material that failed was retreated in the MAECTITE® system.

Material that passed TCLP testing was then loaded into lined gondola railcars, covered and tarped. Railcar scales installed in the spur erected onsite insured that car weight of 100 tons was not exceeded.

To insure that sufficient MAECTITE® reagent was available at all times during treatment operations, Severson utilized two (2) silos for reagent storage on each system. While one unit was in use, the other was serviced. This allowed for continuous treatment without interruption for reagent delivery.

When the Marathon Battery Superfund Site material remediation has been completed later this year (Fall of 1994), approximately 115,000-125,000 cubic yards will have been treated to non-hazardous characteristics by the MAECTITE® chemical treatment process. Total cadmium levels have been found ranging up to 1.36% with TCLP cadmium ranging up to almost 200 mg/l. All material will have been rendered non-hazardous by RCRA definition for characteristically hazardous waste to less than 1.0 mg/l TCLP cadmium by the MAECTITE® process.

## CASE HISTORY II: TRAUB BATTERY AND AUTOBODY SUPERFUND SITE, SIOUX FALLS, SD

Remediation at the Traub Battery and Autobody Superfund Site in Sioux Falls, SD was initiated by the USEPA's ERCS contractor for Region VIII. The site was a former facility that was used to reclaim lead from batteries. The ERCS contractor was utilized to respond to the time critical nature of the site due to migratory lead and exposure risks to human health and the environment. When the contractor demobilized, soil contaminated with hazardous soil for lead had been staged in a pile of approximately 2600 to 2700 cubic yards of material.

USEPA (Region VIII) then utilized the Prequalified Offerors Procurement Strategy's (PQOPS) expedited contracting program to complete site remediation. The PQOPS program established by USEPA (Washington, D.C.) allows for lump sum cost competition for technically approved fixation/stabilization processes offered by contractors for use by the Agency. In order to become technically approved, contractors must submit detailed work plans, fixation/stabilization system designs, former project experiences, project management approaches, Health and

Safety Plans and Quality Assurance Plans to the USEPA (Washington, D.C.) for technical review. Once approved and accepted into the PQOPS program by the USEPA (Washington, D.C.), the contractor is allowed to competitively bid on projects announced in the Commerce Business Daily.

The Traub Battery Site was the first PQOPS contract awarded by USEPA (Washington, D.C./Region VIII) for fixation/stabilization in the United States. The contract required that the staged soil material be treated to comply with the TCLP lead limit of 5.0 mg/l and Multiple Extraction Procedure limits of 5.0 mg/l lead in each of the methods 10 leaching steps. Once successful treatment was verified, material was to be transported to the local municipal licensed non-hazardous landfill for disposal. The site was then to be graded and seeded.

Mobilization and setup of the MAECTITE® system was initiated shortly after USEPA (Region VIII) had approved all site specific work plans and was completed within 5 days after initial site presence. Treatment of the nearly 4000 tons of staged material was completed in less than 10 days. Due to the long duration required for the MEP test results to be generated (15 days), final demobilization was not completed until receipt of final confirmational treatment data, including TCLP and MEP test results.

All material was successfully treated without the need for retreatment to below 5.0 mg/l TCLP lead. Total lead for the site material ranged up to 1256 mg/kg with TCLP lead ranging from 5.6 to 76 mg/l in untreated material. Treated material results for TCLP and MEP methods are presented in Table V.

The MAECTITE® process was successfully applied to the site with mobilization, equipment setup and optimization, full-scale treatment, and equipment demobilization completed in less than 30 days.

## Epilogue

MAECTITE® treated material resembles untreated material in texture and consistency, but has improved structural properties. Often, material volume reduction is observed ranging up to 20 percent. Volume reduction is likely due to chemical rearrangement of the matrix, elimination interstitial soil space, destruction of carbonates, and increased particle density. Since the process is one where reagents cause waste matrix dehydration, the loss of water will also contribute to reductions if proper curing is allowed. Volume increases from MAECTITE® chemical treatment have been limited to approximately 1 percent, with mass increases never observed in excess of 5 percent as a result of MAECTITE® chemical treatment.



TABLE I  
APPLICATION OF MAECTITE® CHEMICAL TREATMENT PROCESS  
TO A DIVERSE VARIETY OF LEAD BEARING WASTE MEDIA

WASTE TYPE (MATRIX)	TOTAL LEAD %	LEACHABLE LEAD (mg/l)	
		Before Treatment	After Treatment
Sandy loam	2.2	163.7	1.5
Lead birdshot	16.1	3,720	ND
Lead buckshot	11.4	1,705	ND
Clayey slag	14.6	91.8	ND
Slag-lead smelter	6.6	21.3	2.0
Topsoil	15.8	44.5	1.4
	14.6	91.8	ND
	0.344	83.5	0.5
Silty sand/debris	0.56	34.6	ND
Battery casings	0.6 - 12	288	0.6
	2.0	160	0.3
Organic humus soil	0.31 - 1.9	23.2	ND
Silty sand	4 - 5	687	0.7
Solid waste	1.1	9.7	0.01
	0.4	72.4	3.4
Sludge-industrial waste	2.2	59.3	1.6
Filter cake	2.9	245.3	1.1
Gravel	0.16	7.5	0.5
Road gravel	0.34	46	ND
Gray clay	2.2	495	0.2
Grayish brown ash	9.5	520	0.3
Brown soil-gravel clay (till)	1.37	263	2.1
Brown soil-gravel sand (till)	3.97	303	1.6
Soil with PbO	29.9	3,659	ND
Clarifier sludge	0.85	57.1	0.3
RCRA organic sludge	9.4	580	ND
Carbon with lead dross	12.6	105.6	0.5
Foundry sand with bentonite	1.96	461.2	ND
Wire fluff	0.33 - 0.134	15.9 - 130	0.7
Wire chip	0.3 - 0.7	28	1.9

TABLE II  
MARATHON BATTERY  
Engineering-Scale Study on High-Level Spiked Material

Sampling Area	Total Cadmium (%)	TCLP Cadmium (mg/l)	
		Untreated	Treated
Marsh	2.93	1596	0.709
Cove	2.9	1050	0.591
Pond	3.11	1072	< 0.1
Plant soil	2.19	1181	< 0.1

All methods by SW-846 procedures

TABLE III  
MARATHON BATTERY  
Role of MAECTITE® Treatment on MEP and EP TOX Cadmium

Source/Type	MEP-Cd (mg/l)*		EP TOX (mg/l)	
	Untreated	Treated	Untreated	Treated
Marsh Sediment	196.9	2.9	20.5	0.5
Plant Ground	58.2	0.81	30.9	0.45
Vault Material	206.9	0.1	76.9	< 0.01
Dredge Sediment	68.5	3.9	21.8	< 0.01

\* MEP results equal sum of all ten extract concentrations  
All methods by SW-846 procedures on unspiked samples

TABLE IV  
MARATHON BATTERY  
Results of Full-Scale MAECTITE® Treatment on Site Material at Marathon Battery

Waste Type (Matrix)	Total Cadmium (%)	TCLP Cadmium (mg/l)	
		Untreated	Treated
EF Cove Material	1.3552	198	BDL
Vault Sediment	0.25 - 14.68	121.3 - 180.2	< 1
Marsh Sediment	0.101	108.8 - 125.2	BDL
Marsh Cinders	0.0168	2.12	ND
Marsh Material	0.0184	9.07	ND

All methods by SW-846 procedures

TABLE V  
 TRAUB BATTERY AND AUTOBODY SUPERFUND SITE (PQOPS)  
 SIOUX FALLS, SOUTH DAKOTA  
 ROLE OF MAECTITE® TREATMENT PROCESS IN CHEMICAL TREATMENT  
 OF LEACHABLE LEAD AS MEASURED BY TCLP\* AND MEP\*\* TESTS

Sample ID# (500 ton lots of treated material)	TCLP LEAD			MEP LEAD	
	CONTRACTOR	EPA	CLP LAB	CONTRACTOR	CLP LAB
1 + 2	BDL <sup>+</sup>	0.46	0.14	0.46	0.85
3 + 4	BDL	0.55		0.57	
5 + 6	BDL	ND <sup>++</sup>		0.61	
7 + 8	BDL	0.47		0.54	
9 + 10	0.27	ND		0.78	
11 + 12	BDL		0.03	0.83	
13 + 14	BDL			0.37	
15 + 16	BDL			0.51	

\* TCLP Test Method 1311, Detection limit as reported by the Pace Laboratory (CLP certified) is 0.025 mg/l.

\*\* MEP Test Method 1320, Detection limit as reported by Pace Lab was 0.025 mg/l.

+ BDL = Below Detection Limit

+ + ND = Non Detectable